CLAIMS

What is claimed is:

1. A circuit package, comprising:

a flange;

at least one lead; and

a frame molded to the flange and to the at least one lead; wherein:

the at least one lead extends through the frame; and

the frame comprises a thermoplastic material having a melting temperature greater than about 340° C.

2. The circuit package of claim 1, wherein:

the frame includes a key having a key profile;

the flange defines an interlock feature having an interlock profile complementary to the key profile; and

wherein the key is in intimate contact with the interlock feature.

3. The circuit package of claim 2, wherein the interlock profile is dovetail shaped.

4. The circuit package of claim 2, wherein the interlock profile is T shaped.

5. The circuit package of claim 2, wherein the interlock profile is L shaped.

6. The circuit package of claim 2, wherein the interlock feature is a groove in the flange.

7. The circuit package of claim 2, wherein the interlock feature stands proud of a surface of the flange.

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8. The circuit package of claim 1, wherein:

the at least one lead defines at least one hole therethrough; and

a portion of the thermoplastic frame material extends through the hole.

9. The circuit package of claim 8, wherein the at least one hole is rectangular.

10. The circuit package of claim 8, wherein the at least one hole comprises a plurality of holes.

11. The circuit package of claim 8, wherein, in a lateral cross-section of the at least one lead and passing through the at least one hole, a cross-sectional area of the at least one hole is less than or equal to about 25% of a cross-sectional area of the at least one lead.

12. The circuit package of claim 1, wherein:

the at least one lead includes a retention feature proximate to one end thereof, the retention feature having an outward-facing portion; wherein

a portion of the thermoplastic frame material abuts the outward-facing portion of the retention feature.

13. The circuit package of claim 12, wherein the retention feature comprises a hooked edge.

14. The circuit package of claim 12, wherein the retention feature comprises a ridge.

15. The circuit package of claim 12, wherein the retention feature comprises a groove.

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16. The circuit package of claim 1, wherein:

the at least one lead includes a retention feature proximate to one end thereof; wherein

a portion of the thermoplastic frame material abuts the retention feature.

17. The circuit package of claim 16, wherein the retention feature is a hooked edge.

18. The circuit package of claim 16, wherein the retention feature is a ridge.

19. The circuit package of claim 16, wherein the retention feature is a groove.

20. The circuit package of claim 1, wherein the flange comprises a convex bottom surface.

21. The circuit package of claim 20, wherein the convexity of the bottom surface is at least about 0.0001 inches.

22. The circuit package of claim 20, wherein the convexity of the bottom surface is between about 0.0005 and about 0.0010 inches.

23. The circuit package of claim 1, wherein the flange comprises at least 50% copper.

24. The circuit package of claim 1, wherein the flange comprises at least 90% copper.

25. The circuit package of claim 1, wherein the flange comprises at least about 98% copper.

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26. The circuit package of claim 1, wherein the flange comprises an alloy of copper and at least one material chosen from a group comprising zirconium and silver.

27. The circuit package of claim 26, wherein the alloy contains at least about 98% copper.

28. The circuit package of claim 1, wherein the flange comprises:

between about 0.05% and about 1.5% zirconium; and
at least about 98.5% copper.

29. The circuit package of claim 1, wherein the flange comprises:

between about 0.05% and about 1.5% zirconium; and
the balance copper.

30. The circuit package of claim 1, wherein the flange comprises:

at about 0.085% silver; and
at least about 99.9% copper.

31. The circuit package of claim 1, wherein the at least one lead comprises at least 50% copper.

32. The circuit package of claim 1, wherein the at least one lead comprises at least 97% copper.

33. The circuit package of claim 1, wherein the at least one lead comprises an alloy of copper and at least one material chosen from a group comprising iron, phosphorus, zinc, zirconium, cobalt, tin, magnesium, nickel, chromium, titanium and silicon.

34. The circuit package of claim 33, wherein the alloy contains at least 97% copper.

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35. The circuit package of claim 1, wherein the at least one lead comprises:

between about 2.1% and about 2.6% iron;

between about 0.015% and about 0.15% phosphorous;

between about 0.05% and 0.2% zinc; and

the balance copper.

36. The circuit package of claim 1, wherein the thermoplastic material comprises a liquid crystal polymer.

37. The circuit package of claim 2, wherein the liquid crystal polymer comprises:

para-hydroxybenzoic acid;

bisphenol; and

phathalic acid.

38. The circuit package of claim 2, wherein the liquid crystal polymer comprises:

a copolymer of p-hydroxybenzoic acid; and

6-hydroxy-2-naphthoic acid.

39. The circuit package of claim 2, wherein the liquid crystal polymer comprises terapolymers of formulation hydroxybenzoic acid, 4-4-bisphenol and terephthalic acid.

40. The circuit package of claim 1, wherein the thermoplastic material has a coefficient of thermal expansion within 60% of a coefficient of expansion of the at least one lead.

41. The circuit package of claim 1, wherein the thermoplastic material has a coefficient of thermal expansion of between about 7 ppm/°C and 22 ppm/°C.

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42. The circuit package of claim 1, wherein the thermoplastic material comprises between about 30% and about 45% talc balls between about 2 and about 3 microns in diameter.

43. The circuit package of claim 1, wherein the thermoplastic material comprises between about 30% and about 50% glass fiber.

44. The circuit package of claim 1, wherein the thermoplastic material comprises a plurality of graphite flakes.

45. The circuit package of claim 44, wherein the thermoplastic material comprises between about 10% and about 70% graphite flakes.

46. The circuit package of claim 44, wherein the thermoplastic material comprises between about 40% and about 50% graphite flakes.

47. The circuit package of claim 44, wherein the graphite flakes form a plurality of layers.

48. The circuit package of claim 47, wherein the graphite flakes are oriented parallel to a selected surface of the frame.

49. The circuit package of claim 1, further comprising a thermoplastic material lid attached to the frame.

50. The circuit package of claim 49, wherein the flange, the frame and the lid define an air cavity.

51. The circuit package of claim 49, wherein the lid is welded to the frame.

52. The circuit package of claim 49, wherein the thermoplastic material comprises a liquid crystal polymer.

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53. The circuit package of claim 52, further comprising a semiconductor die attached to the flange and electrically bonded to the at least one lead.

54. The circuit package of claim 52, wherein the thermoplastic material comprises a plurality of graphite flakes.

55. The circuit package of claim 54, wherein the thermoplastic material comprises between about 10% and about 70% graphite flakes.

56. The circuit package of claim 54, wherein the thermoplastic material comprises between about 40% and about 50% graphite flakes.

57. The circuit package of claim 1, further comprising a semiconductor die attached to the flange and electrically bonded to the at least one lead.

58. The circuit package of claim 1:

wherein the frame comprises an edge adjacent a surface of the flange; and

further comprising a seal attached to the frame and to the flange along at least a portion of the edge.

59. The circuit package of claim 58, wherein the seal comprises epoxy.

60. The circuit package of claim 58, wherein the seal comprises silicone.

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61. The circuit package of claim 1:

wherein the frame comprises a first edge adjacent a first surface of the at least one lead; and

further comprising a first seal attached to the frame and to the at least one lead along at least a portion of the first edge.

62. The circuit package of claim 61:

wherein the frame comprises a second edge adjacent a second surface of the at least one lead; and

further comprising a second seal attached to the frame and to the at least one lead along at least a portion of the second edge.

63. The circuit package of claim 62:

wherein the frame comprises a third edge adjacent a surface of the flange; and

further comprising a third seal attached to the frame and to the flange alone at least a portion of the third edge along.

64. The circuit package of claim 63, wherein the seal comprises epoxy.

65. The circuit package of claim 63, wherein the seal comprises silicone.

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66. The circuit package of claim 63, wherein the seal comprises a material having:

a thixotropic index between 3.5 and 4.6;

a cason viscosity between 7.4 and 3 Pa.s;

a viscosity between 58 and 125 Pa.s at a shear rate of 0.95 per second; and

a viscosity between 12 and 30 Pa.s at a shear rate of 9.5 per second.

67. The circuit package of claim 1, further comprising a moisture barrier film on a surface of the frame.

68. A flange for mounting a semiconductor die, comprising:

a solid metallic body having:

a central planar die-attach area on a first side thereof, the die-attach area being flat to within about 0.005 inches per inch and having a surface roughness less than about 64 micro-inches; and

a second side, opposite the first side, having a surface roughness less than about 64 micro-inches; wherein:

the metallic body comprises at least 50% copper.

69. The flange of claim 68, wherein the metallic body defines a plurality of openings by which the flange can be mounted to a substrate.

70. The flange of claim 68, wherein the metallic body comprises at least 90% copper.

71. The flange of claim 68, wherein the metallic body comprises at least about 98% copper.

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72. The flange of claim 68, wherein the metallic body comprises an alloy of copper and at least one material chosen from a group comprising zirconium and silver.

73. The flange of claim 68, wherein the metallic body comprises an alloy containing at least about 98% copper.

74. The flange of claim 73, wherein the alloy contains between about 0.05% and about 1.5% zirconium and at least about 98.5% copper.

75. The flange of claim 73, wherein the alloy contains about 0.085% silver and at least about 99.9% copper.

76. The flange of claim 68, wherein the metallic body includes a recess that defines at least one undercut portion.

77. The flange of claim 76, wherein the recess includes a portion having a dovetail-shaped cross-section.

78. The flange of claim 76, wherein the recess includes a portion having a T-shaped cross-section.

79. The flange of claim 76, wherein the recess includes a portion having an L-shaped cross-section.

80. The flange of claim 68, wherein the metallic body includes a ridge that defines at least one undercut portion.

81. The flange of claim 80, wherein the ridge includes a portion having a dovetail-shaped cross-section.

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82. The flange of claim 80, wherein the ridge includes a portion having a T-shaped cross-section.

83. The flange of claim 80, wherein the ridge includes a portion having an L-shaped cross-section.

84. The flange of claim 68, wherein the second side of the body is convex.

85. The flange of claim 84, wherein convexity of the second side is at least about 0.0001 inches.

86. The flange of claim 84, wherein convexity of the second side is between about 0.0005 and about 0.0010 inches.

87. A flange for mounting a semiconductor die, comprising:

a solid metallic body having:

a central planar die-attach area on a first side thereof, the die-attach area being flat to within about 0.005 inches per inch and having a surface roughness less than about 64 micro-inches; and

a second side, opposite the first side, has a surface roughness less than about 64 micro-inches and is convex.

88. The flange of claim 87, wherein the metallic body defines a plurality of openings by which the flange can be mounted to a substrate.

89. The flange of claim 87, wherein convexity of the second side is at least about 0.0001 inches.

90. The flange of claim 87, wherein convexity of the second side is between about 0.0005 and about 0.0010 inches.

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91. The flange of claim 87, wherein the metallic body comprises at least 50% copper.

92. The flange of claim 87, wherein the metallic body comprises at least 90% copper.

93. The flange of claim 87, wherein the metallic body comprises at least about 98% copper.

94. The flange of claim 87, wherein the metallic body comprises an alloy of copper and at least one material chosen from a group comprising zirconium and silver.

95. The flange of claim 87, wherein the metallic body comprises an alloy containing at least about 98% copper.

96. The flange of claim 95, wherein the alloy contains between about 0.05% and about 1.5% zirconium and at least about 98.5% copper.

97. The flange of claim 95, wherein the alloy contains about 0.085% silver and at least about 99.9% copper.

98. A flange for mounting a semiconductor die, comprising:

a solid metallic body having:

a central planar die-attach area on a first side thereof, the die-attach area being flat to within about 0.005 inches per inch and having a surface roughness less than about 64 micro-inches; and

a second side, opposite the first side, having a surface roughness less than about 64 micro-inches; wherein:

the metallic body includes a recess that defines at least one undercut portion.

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99. The flange of claim 98, wherein the metallic body defines a plurality of openings by which the flange can be mounted to a substrate.

100. The flange of claim 98, wherein the recess includes a portion having a dovetail-shaped cross-section.

101. The flange of claim 98, wherein the recess includes a portion having a T-shaped cross-section.

102. The flange of claim 98, wherein the recess includes a portion having an L-shaped cross-section.

103. The flange of claim 98, wherein the metallic body comprises at least 50% copper.

104. The flange of claim 98, wherein the metallic body comprises at least 90% copper.

105. The flange of claim 98, wherein the metallic body comprises at least about 98% copper.

106. The flange of claim 98, wherein the metallic body comprises an alloy of copper and at least one material chosen from a group comprising zirconium and silver.

107. The flange of claim 98, wherein the metallic body comprises an alloy containing at least about 98% copper.

108. The flange of claim 107, wherein the alloy contains between about 0.05% and about 1.5% zirconium and at least about 98.5% copper.

109. The flange of claim 108, wherein the alloy contains about 0.085% silver and at least about 99.9% copper.

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110. A flange for mounting a semiconductor die, comprising:

a solid metallic body having:

a central planar die-attach area on a first side thereof, the die-attach area being flat to within about 0.005 inches per inch and having a surface roughness less than about 64 micro-inches; and

a second side, opposite the first side, having a surface roughness less than about 64 micro-inches; wherein:

the metallic body includes a ridge that defines at least one undercut portion.

111. The flange of claim 110, wherein the metallic body defines a plurality of openings by which the flange can be mounted to a substrate.

112. The flange of claim 110, wherein the ridge includes a portion having a dovetail-shaped cross-section.

113. The flange of claim 110, wherein the ridge includes a portion having a T-shaped cross-section.

114. The flange of claim 110, wherein the ridge includes a portion having an L-shaped cross-section.

115. The flange of claim 110, wherein the metallic body comprises at least 50% copper.

116. The flange of claim 110, wherein the metallic body comprises at least 90% copper.

117. The flange of claim 110, wherein the metallic body comprises at least about 98% copper.

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118. The flange of claim 110, wherein the metallic body comprises an alloy of copper and at least one material chosen from a group comprising zirconium and silver.

119. The flange of claim 110, wherein the metallic body comprises an alloy containing at least about 98% copper.

120. The flange of claim 119, wherein the alloy contains between about 0.05% and about 1.5% zirconium and at least about 98.5% copper.

121. The flange of claim 120, wherein the alloy contains about 0.085% silver and at least about 99.9% copper.

122. A lead for a semiconductor circuit package, comprising a metal conductor and defining a plurality of laterally spaced holes therethrough.

123. The lead of claim 122, wherein each of the plurality of holes is rectangular.

124. The lead of claim 123, wherein, in a lateral cross-section of the lead and passing through the plurality of holes, a cross-sectional area of the plurality of holes is less than or equal to about 25% of a cross-sectional area of the lead.

125. The lead of claim 122, further comprising a frame molded thereto, a portion of the frame extending through the plurality of holes.

126. The lead of claim 125, wherein the frame comprises a liquid crystal polymer.

127. The lead of claim 122, wherein the lead comprises at least 50% copper.

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128. The lead of claim 122, wherein the lead comprises at least 97% copper.

129. The lead of claim 122, wherein the lead comprises an alloy of copper and at least one material chosen from a group comprising iron, phosphorus, zinc, zirconium, cobalt, tin, magnesium, nickel, chromium, titanium and silicon.

130. The lead of claim 129, wherein the alloy contains at least 97% copper.

131. The lead of claim 122, wherein the lead comprises:

between about 2.1% and about 2.6% iron;
between about 0.015% and about 0.15% phosphorous;
between about 0.05% and 0.2% zinc; and
the balance copper.

132. A lead for a semiconductor circuit package, comprising a metal conductor having a lead retention feature proximate to one end thereof.

133. The lead of claim 132, wherein:

the lead retention feature comprises an outward-facing portion; and further comprising:

a frame molded to the metal conductor, a portion of the frame abutting the outward-facing portion of the lead retention feature.

134. The lead of claim 133, wherein the frame comprises a liquid crystal polymer.

135. The lead of claim 132, wherein the retention feature comprises a hooked edge.

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136. The lead of claim 132, wherein the retention feature comprises a ridge.

137. The lead of claim 132, wherein the retention feature comprises a groove.

138. The lead of claim 132, wherein the lead comprises at least 50% copper.

139. The lead of claim 132, wherein the lead comprises at least 97% copper.

140. The lead of claim 132, wherein the lead comprises an alloy of copper and at least one material chosen from a group comprising iron, phosphorus, zinc, zirconium, cobalt, tin, magnesium, nickel, chromium, titanium and silicon.

141. The lead of claim 140, wherein the alloy contains at least 97% copper.

142. The lead of claim 132, wherein the lead comprises:

between about 2.1% and about 2.6% iron;
between about 0.015% and about 0.15% phosphorous;
between about 0.05% and 0.2% zinc; and
the balance copper.

143. The lead of claim 142, wherein the retention feature comprises a hooked edge.

144. The lead of claim 142, wherein the retention feature comprises a ridge.

145. The lead of claim 142, wherein the retention feature comprises a groove.

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146. A method for enclosing a circuit package, comprising ultrasonically welding a thermoplastic material lid to a thermoplastic material frame of the circuit package using a welding signal having a frequency between about 50 KHz and about 60 KHz and an amplitude less than about 100 microns.

147. The method of claim 146, wherein the amplitude is less than about 60 microns.

148. A method for enclosing a circuit package, comprising laser welding a thermoplastic material lid to a thermoplastic material frame of the circuit package.

149. A method for enclosing a circuit package, comprising thermal welding a thermoplastic material lid to a thermoplastic material frame of the circuit package.

150. A method for fabricating a flange of a circuit package, comprising:

forming the flange from a material comprising at least about 50% copper.

151. The method of claim 150, wherein the material comprises at least about 90% copper.

152. The method of claim 150, wherein the material comprises at least about 98% copper.

153. The method of claim 150, wherein the material comprises an alloy of copper and at least one material chosen from a group comprising zirconium and silver.

154. The method of claim 150, wherein the material comprises between about 0.05% and about 1.5% zirconium and at least about 98.5% copper.

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155. The method of claim 150, further comprising:

coining a frame retention feature into a first surface of the flange.

156. The method of claim 155, wherein the frame retention feature includes an undercut portion.

157. The method of claim 156, further comprising:

imparting a convex shape to a second surface, opposite the first surface, of the flange.

158. The method of claim 157, wherein convexity of the second surface is at least about 0.0001 inches.

159. The method of claim 157, wherein convexity of the second surface is between about 0.0005 and about 0.0010 inches.

160. A method for fabricating a lead of a circuit package, comprising:

stamping a lead frame from a material comprising at least about 50% copper.

161. A thermoplastic material, comprising:

a liquid crystal polymer; and

a plurality of graphite flakes.

162. The thermoplastic material of claim 161, wherein the thermoplastic material comprises between about 10% and about 70% graphite flakes.

163. The thermoplastic material of claim 161, wherein the thermoplastic material comprises between about 40% and about 50% graphite flakes.

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164. The thermoplastic material of claim 162, wherein the liquid crystal polymer comprises:

para-hydroxybenzoic acid;

bisphenol; and

phathalic acid.

165. The thermoplastic material of claim 162, wherein the liquid crystal polymer comprises:

a copolymer of p-hydroxybenzoic acid; and

6-hydroxy-2-naphthoic acid.

166. The thermoplastic material of claim 162, wherein the liquid crystal polymer comprises terapolymers of formulation hydroxybenzoic acid, 4-4-bisphenol and terephthalic acid.

167. A structure comprising:

a composition of matter comprising:

a liquid crystal polymer; and

a plurality of graphite flakes; wherein

the structure has a surface and the plurality of graphite flakes are parallel to the surface.

168. A method for making a structure, comprising:

injecting into a mold a composition of matter comprising:

a liquid crystal polymer; and

a plurality of graphite flakes.

169. The method of claim 168, wherein the composition of matter comprises between about 10% and about 70% graphite flakes.

170. The method of claim 168, wherein the composition of matter comprises between about 40% and about 50% graphite flakes.

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171. The method of claim 168, wherein the structure includes a surface; and the composition is injected such that, after the injecting, the plurality of graphite flakes

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